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AN ELECTRICAL METHOD FOR OBTAINING OXYGEN

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THE ELECTROLYSIS OF WATER AND THE OBTAINING OF OXYGEN  
*(From the Materials from the Department of Defense Planning Bureau)*

Note: Only Section 2 is translated here.

By sending a direct current through water, to which has been added  $\text{H}_2\text{SO}_4$ , or alkali to increase the electrical conductivity, one can cause the water to decompose into oxygen and hydrogen. This process is called electrolysis. The scheme is shown in Figure 17. Hydrogen is evolved at the negative electrode (cathode), and the oxygen is at the positive (anode). (All figures shown in Annex). At the negative electrode (cathode), and the oxygen is at the positive (anode). Here the volume of hydrogen are released for every one volume of oxygen. The so-called water molecule ( $\text{H}_2\text{O}$ ) consists of 2 parts by weight of hydrogen and 16 of oxygen; thus water decomposes into 1 part hydrogen and 8 parts oxygen by weight.

*notwirk*  
 The electrolysis of water was discovered early as 1779 by the chemists Tretvick and Payman /fig. 7/; however, the first apparatus for electrolysis was made only in 1805 by the French scientist D'Arsonval.

As early as 1899 Schmidt-- and Sheep in 1900-- created an industrial types of electrolyzers which are still being successfully used even up to the present time (with a number of improvements in design).

In order to obtain, theoretically, 1  $\text{m}^3$  of  $\text{O}_2$  and 2  $\text{m}^3$   $\text{H}_2$ , it is necessary to consume 6700 amper-hours. In practice, the expenditure of energy is from 11 to 13 kilowatt-hours (kwh) per 1  $\text{m}^3$  of  $\text{O}_2$  and 2  $\text{m}^3$  of  $\text{H}_2$ . In order to obtain a constant flow it is necessary to employ mercury rectifiers or motor-generators. Electrolyzers are not filled with pure water, but with a 20% solution of  $\text{NaOH}$ . The oxygen obtained has a purity of 98-99%.

The defect in the electrolytic method of obtaining oxygen is the large expenditure of electrical energy, which requires the ~~possibility~~ of considerable quantities of cheap electrical energy, since otherwise oxygen is obtained ~~at great a cost~~. In consequence of this, the given method had not received sufficiently wide distribution as an industrial means for obtaining oxygen. Moreover, large-output electrolyzers require considerable space for their installation.

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Individual large-scale electrolytical plants employed to produce hydrogen obtain oxygen at the same time, which in this case is a by-product.

One of the largest electrolyzer plants is in Norway, with about 65000-kilowatt capacity; it produces about 6000 m<sup>3</sup> of O<sub>2</sub> and 15000 m<sup>3</sup> of H<sub>2</sub> per hour.

Recently there has begun the practice of electrolyzing water under high pressures of the order of 50 to 200 atm (atmospheres), which reduces somewhat the expenditure of electrical energy and makes unnecessary the subsequent compression in compressors of the obtained oxygen for filling gas cylinders with it or for distributing it in conduits.

In order to obtain a small quantity of oxygen and hydrogen for the purposes of oxyacetylene welding and cutting when a source of constant (direct) electrical current is available, one can make use of small medium-pressure electrolyzers. (Note: The design and construction has been worked out in OSPI-) by Engineers L. I. Osnin, A. I. Kolesakov, I.-M. Yakimenko, et alii; Certificates of Authorship Nos. 14309 and 51206. The technical data and schematic diagrams of the installation are copied by us from an article by Engineer I. M. Yakimenko in the periodical "Kislorod" No. 2, for 1945 (Translated in full.)

Figure 18 represents a schematic diagram of this electrolytic installation, which is designed to obtain oxygen and hydrogen under a pressure up to 12-15 atm and is <sup>under</sup> ~~presently~~ <sup>in</sup> operation ~~in~~ at a number of factories.

The technical characteristics of this type of installation are shown in Table 1b. Direct current is supplied to the electrolyzer 1 (Figure 18) from a mercury rectifier or water-generator over resistors 2 and 3.

The hydrogen and oxygen fuming in the electrolyzer 1 are collected separately into two collectors 4 and pass through separating (distributing) columns 5, where they are cooled and freed of alkali particles. After that, the gases arrive at bubbler-type distributors 6, which are connected in series with the resistors 7 and 8; from here the gases are fed into the "consumption network" under a pressure the same as that in the electrolyzer.

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The alkali from the separator 5 is passed through a filter 9 and from there it is directed to a lower collector of the electrolyzer. To replenish the water lost in the electrolyzer, distilled or condensate water is used, which is added to the system from a tank 10. The cooling water in the coils of the separator columns 5 and reservoirs 6 are supplied from ordinary pipes.

The electrolyzer is made like a sort of filter-press and consists of a large number of flat circular cells or compartments 1 (Figures 19 and 20), which are held tightly together by four strong bolts 2 and by two terminal plates 3. Between the cells are interlaid 'parasite' washers or gaskets 4, which clamp iron disk-like electrodes 5 to electrodes 7, on intermediate contacts 6, which (electrodes 7) serve to decrease the tension (voltage) on the main electrode.

Inside of the cells 5 are frames 8, to which asbestos diaphragms 9 are attached. Each electrode 5 operates bipolarly; that is, one side of it with one 'supporting' electrode operates in one cell as a negative pole (cathode) and collects hydrogen on itself; the other side with the second 'supporting' electrode operates in another cell as a positive pole (anode) and releases oxygen on its surface. By means of charcoal and pipes 10 and 11, these gases are drawn off to corresponding collectors 12 for collecting  $H_2$  and  $O_2$ .

In order that not too great a difference in the pressures on both sides of the diaphragm <sup>with +</sup> ~~should appear~~, which (pressure difference) might ~~cause~~ <sup>cause</sup> the rupture of the diaphragm, the installation is provided with automatic regulators—namely, pressure equalizers which ensure a difference in the pressures of the gases on both sides of the diaphragm not greater than that corresponding to a 100-200 mm water column; the such regulators are placed in the oxygen and hydrogen sides. These regulators 13 are connected in parallel with the contacts 6 and consist of two pumps with floats (Figure 18). When a difference in gas pressure occurs in the system, the water levels in the containers 6 and pump 13 are displaced, and the corresponding

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proper float, in floating. Suitable channel is used as an exit, or output, from the chamber of the electrolyzers for that gas whose pressure has been lowered.

The cells of the electrolyzer are connected in series. The voltage in each cell is 2.8 - 2.25 volts. The oxygen is obtained with a purity of 90 to 90.5%; the hydrogen is 99 to 99.5% pure. The expenditure of energy (direct current) is 11.0 to 11.5 kilowatt-hours (kwh) per 1 m<sup>3</sup> of oxygen and 1 m<sup>3</sup> of hydrogen /MIG/, or 12 to 15 kwh for alternating current. When the temperature in the electrolyzer rises 1°C, then the voltage in a cell and expenditure of energy is decreased by 0.25%.

The yield is regulated by varying the voltage of the direct current feeding the electrolyzer. Servicing is very simple and consists of: a) periodic supplying of feed water and b) regulating of the cooling water for maintaining an assigned temperature of the bath.

This type of installation tolerates prolonged overloads up to 30-35%, with the yield increasing by a similar amount. The electrolyte employed is a 20-22% solution of NaOH or 28-30% solution of KOH. The temperature in the electrolyzer equals 30-80° when in operation.

The cost of an installation unit (one plant) consisting of three electrolyzers of the FK-12/115 type is around 220,000 rubles. Of this amount, the part (building) including building and sanitation amounts to 30,000 rubles; technological equipment and outfitting cost 150,000 rubles; and electrical equipment is 40,000 rubles. The building requires a space of 120 m<sup>2</sup> (without counting the transformer substation). The expenditure of caustic sodas is about 5.5 to 6 grams per 1 m<sup>3</sup> of O<sub>2</sub> and 2 m<sup>3</sup> of H<sub>2</sub>, and consumption of feed water is 1.8 liters. The consumption of cooling water is 60 to 200 liters per 1 m<sup>3</sup> of O<sub>2</sub>. The cost of the oxygen and hydrogen obtained depends upon the cost of the electrical energy and the capacity of the plant and fluctuates between 1.5 and 3 rubles per 1 m<sup>3</sup> of O<sub>2</sub> and 2 m<sup>3</sup> of H<sub>2</sub>.

End of Section 7~~CONFIDENTIAL~~

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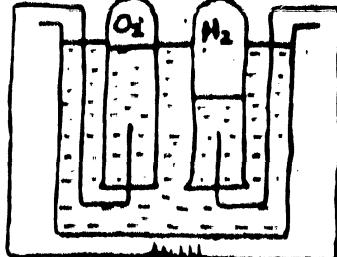


Figure 17: Schematic Diagram of the Method for Obtaining Oxygen and Hydrogen Electrolytically.

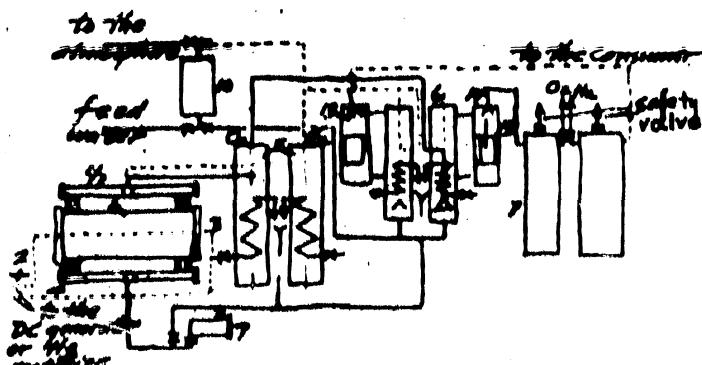


Figure 18: Electrolyzer Plant for Obtaining Oxygen and Hydrogen.

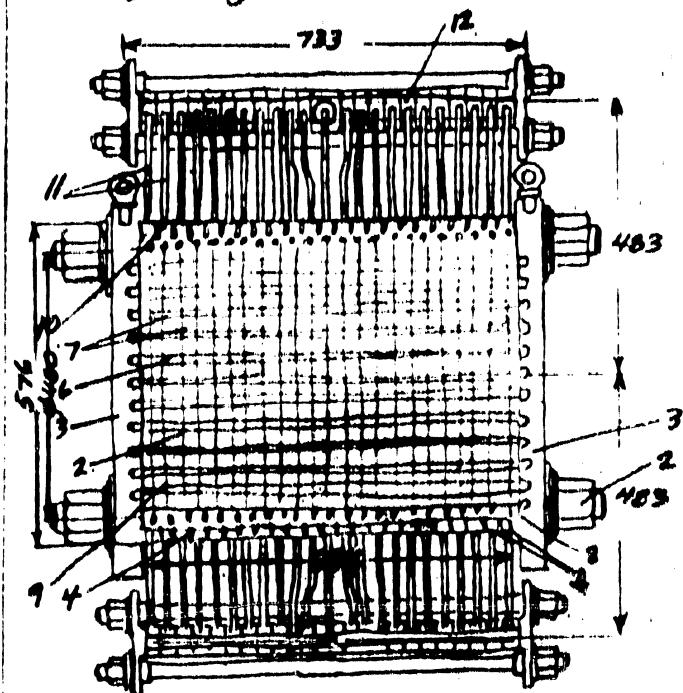
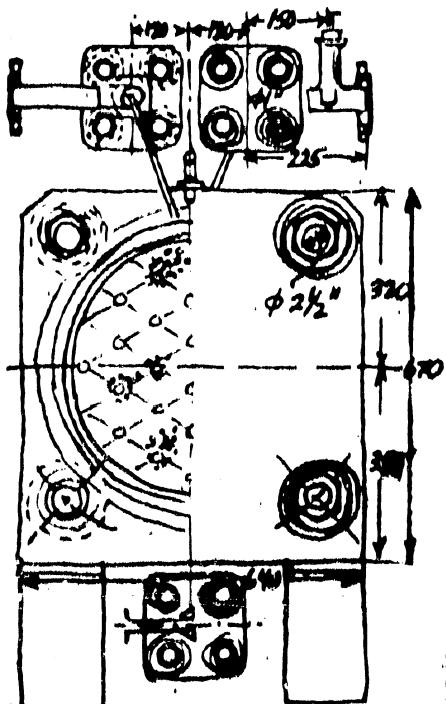


Figure 19: Longitudinal cross-section of a bipolar-type electrolyzer.



Cross-Section I-I  
Figure 20. Side View and Cross Section of the Electrolyzer in Figure 19.

[Note: Table 14 follows.]

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**Table 14**  
**The Technical Characteristics of Medium-Pressure  
 Electrolyzer Installations:**

Type	Voltage in the Electro- lyzer	Rated Load (in amp.)	Max press. (in atm.)	No. of Cells	Yield	
					O <sub>2</sub>	H <sub>2</sub>
FK-12	230 volts	600	12	100	12	24
FK-12/115	115	600	12	50	6	12
FK-6	230	300	15	100	6	12
FK-6/115	115	300	15	50	3	6
F-97-50-1	230	1200	1	97	24	48

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